

Losses in gum Arabic from *Acacia Senegal* inflicted by the Tree Locust *Anacridium melanorhodon melanorhodon* (Orthoptera: Acrididae)

Haroon, W. M.,^a * Abdalla M. A.,^a Vassal, J. ^b & Lecoq, M. ^b

^aDepartment of Plant Protection, University of Kordofan, P.O. Box 160, El Obeid, Sudan

^bCIRAD Acridologie, F-34398, Montpellier, France

Corresponding Author: wailharoon@yahoo.com

Abstract

This study was conducted in North Kordofan, Sudan during the season 2013\2014. The study aimed at assessing losses in gum productivity of *Acacia senegal* (g/tree) inflicted by the tree locust *Anacridium melanorhodon melanorhodon*. Experiments were conducted in *A. senegal* plantation, where big cages were installed on 12 trees with subsequent level of artificial infestation of: 0, 15, 30 and 60 locust/cage in three replicates. The caged trees were tapped and then gum picking was performed. The obtained gum from each tree was separately weighed. The same set of the experiment was replicated in another separate site. Results revealed that infestation by 60 locusts/tree caused 70% and 81% loss reduction at the two sites, respectively. The respective loss inflicted by 30 locust/tree was 58% and 39%, respectively. The study concluded that the tree locust inflicted serious damage to *A. senegal* trees which leads to severe losses in gum productivity.

Keywords: *Acacia senegal*, Tree Locust, Gum losses, Sudan

Résumé

Cette étude a été réalisée dans le nord du Kordofan, au Soudan, au cours de la saison 2013 \ 2014. L'étude visait à évaluer les pertes de productivité en gomme d'*Acacia senegal* (g/arbre) infligées par le criquet pèlerin *Anacridium melanorhodon melanorhodon*. Des expériences ont été menées dans la plantation d'*A. Sénégal*, où de grandes cages ont été installées sur 12 arbres avec un niveau d'infestation artificielle subséquent de: 0, 15, 30 et 60 criquets / cages en trois répétitions. Les arbres en cage ont été exploités puis une cueillette de gomme a été effectuée. La gomme obtenue de chaque arbre a été pesée séparément. La même expérience a été reproduite dans un autre site distinct. Les résultats ont révélé que l'infestation par 60 criquets / arbre a entraîné une réduction des pertes de 70% et 81% aux deux sites, respectivement. Les pertes respectives infligées par 30 criquets / arbres étaient respectivement de 58% et 39%. L'étude a conclu que le criquet pèlerin avait gravement endommagé les arbres d'*A. Senegal*, entraînant de graves pertes de productivité des gencives.

Mots-clés: *Acacia senegal*, Criquet pèlerin, Pertes de gomme, Soudan

Introduction

The world wide known Gum Arabic is a non timber forest product that comes as exudates from the stem and branches of *Acacia senegal* (locally known as Hashab tree). Gum Arabic is considered as the main natural product in the traditional rain-fed agricultural sub-sector of Sudan. According to FAO (1999) Sudan accounts for 80% of the world's gum Arabic production and boasts to be the world main source of gum Arabic in Sudan (gum Hashab). Kordofan Region alone is responsible for 70 % of the national production of gum Arabic (Jamal and Albany, 1994). *Acacia senegal* tree and Gum Arabic production is regarded as the most important socio-economic and ecological components in the savannah belt of the Sudan. In addition to gum production, *Acacia senegal* tree ameliorates soil through biological nitrogen fixation, as well as provides a source of firewood and fodder (Badi *et al.*, 1989; Elfeel, 1996). Moreover the Gum Arabic belt acts as a natural barrier against the desert encroachment (Ballal, 2003). Gum Arabic production activities contributes substantially to the income of small local farmers in the area and it is considered as a pillar of family economy and as an income-generating source that requires only a low input of work after the rainy season (Mahmoud, 2004). Moreover, gum Arabic plays an important role in rural life by providing a steady income to rural families especially in dry years when crops fail (FAO, 1999).

Gum Arabic production is seriously constrained by the tree locust *Anacridium melanorhodon melanorhodon* also called the "night wanderer" as the locust swarms are flying by night-in addition to some other biotic and abiotic factors. This locust been reported by FAO (1993) as a regular inhabitant of the Sahelian zone and is considered as important pest of *Acacia senegal*. Tigani (1965) and Popov and Ratcliffe (1968) reported that Sudan is considered as a main distribution area of *A. m. melanorhodon*, with an observed overlap with the other subspecies, *A. m. arabafrum* (Dirsh) in eastern Sudan and western Eritrea (Anonymous, 1976). The tree locust spreads on a broad scale, copiously in the South-West of Darfur and Kordofan States where it is considered as a serious pest (Johnston, 1932). It mainly attacks Gum Arabic plants where this pest, as reported by the Anti Locust Research Centre (1966), is considered as the most destructive pest to *Acacia senegal* tree.

The economic importance of the Tree locust in gum production in the Sudan has been studied by El Zain (1994), and the main losses in gum production caused by Tree locust in seasons 1991/92 and 1992/93 was estimated at 86.5% at Umruaba Province, North Kordofan State, Sudan. Elamin *et al.* (2008) concluded that the Gum Arabic tree (hashab tree), suffers when attacked by the tree locust during years of outbreak, and the defoliation caused by this pest reduces the gum yield causing significant economic losses. However, the relation between *Acacia* and Tree locust, the consequences of defoliation and the real impact of the Tree locust on gum productivity is not well documented. Therefore, there is a necessity to investigate and estimate the damage caused by such pest as a prerequisite for control measurements. The current study was designed to assess the impact of tree locust and to quantify the losses on gum productivity (g/tree) of *Acacia senegal* in north Kordofon State, Sudan.

Research Approach

The present work was carried out during the period 2011 to 2014. The experiment was conducted in Acacia agricultural project at South East El Obeid, North Kordofan State, Sudan and replicated in another separate site belongs to the same project. A social survey was conducted in three villages within the gum Arabic belt in North Kordofan State.

Two sets of field experiments were conducted in gum Arabic plantation belonging to Acacia Agricultural Company in North Kordofan State, Sudan during the period extending from August 2013 to February 2014. Two separate locations within Acacia company plantations were chosen, the first location (Nawa) lies 37 km South East of El Obeid and the second location (Rahad) 57 km South East of El Obeid), North Kordofan State, Sudan. The soil of the two areas is a hard non-cracking sandy clay soil locally named as Gardudsoil. The area receives an annual rainfall ranging between 300 – 350 mm. The area ha 2570 were planted with *Acacia senegal* trees since 2003 with an average of 1100 tree/ha.

The site was surveyed for selection of the trees for artificial infestation with the tree locust and subsequently ten years old trees were selected. Some measurements were conducted on the selected trees in order to have the maximum possible homogeneity; these measurements were: Height (Hypsometer); Crown (Distance tape); Stem Diameter DBH, (Caliber) and Coordinates (GPS).

In the two locations 24 trees (12 each) were selected and covered, at the same time, with wire mesh square cages (2x2x2.5m) with well locked doors. In each cage there was label in which the tree number, treatment and location number were marked (Fig.1). The collection of tree locust nymphs started late August and continued for four days, about 750 of *Anacridium* 5th instar nymphs were collected, kept inside small cages and fed with Acacia leaves on daily basis.



Figure 1. Experimental cages over the selected trees

At the beginning of September, when the collected nymphs reached the soft adult stage, they were put inside the cages at the same time at both locations. Four levels of infestation were tested to estimate the loss in gum production due to the defoliation caused by the tree locust. These levels were (0, 15, 30 and 60 adults/tree) with three replicates for each level in the two locations. In each cage, the male/female ratio was 1:1. The number of locusts per cage was maintained at the same level and whatever natural mortality by introduction occurred of additional imagoes were added. Zero level of infestation was considered as untreated control. The treatments were distributed randomly among the selected trees using Complete Randomized Design (CRD). The data collected were subjected to analysis of variance (ANOVA) table was used for data analysis.

On the 15th of October, all the caged trees were tapped using a small axe locally known as Farrar. Tapping process was performed by one person throughout the experiment with fixed tapping percentage estimated at (50%). Forty days later, the collection of gum exudates commenced from first pick up to six picks with 15 days interval. The obtained gum from each tree was taken directly to the laboratory for weighing using sensitive balance manufactured by A&D Co. Ltd. Japan.

Results

Table (1) shows the effect of different densities of *Anacridium m. melanorhodon* adults on the mean production (in g) of *Acacia senegal* trees after six collections. There were significant differences between the control and 15, 30 and 60 adult locust/tree, the negative effect of the high density of locust on gum productivity was pronounced.

Table 1. Cumulative mean gum production (g) of *Acacia senegal* tree infested with various densities of *Anacridium m. melanorhodon* adults in Nawa site (season 2013/2014)

Adult locust density/tree	Cumulative mean production (g)
0	377.15 ^a
15	253.43 ^b
30	160.85 ^{bc}
60	70.50 ^c
SE±	48.8
CV%	27.8

Means followed by the same letters are not significantly different at $P \leq 0.05$ using LSD

In Nawa site, there were significant differences between all the treatments and the Control in the 1st collection with highly significant difference between the control and the density of 60 locust/tree. For the 2nd and 3rd collections, there were significant differences between the gum production obtained between the treatments 30 and 60 locust/tree and the control, while at 4th collection the significant differences were obtained only between the treatment 60 locust/tree and the control. In the 5 and 6 collections there was no significant difference obtained between all the treatments and control. On the other hand infestation with 15 locusts/tree caused no significant effect on the gum production from the 2nd collection up to the 6th one (Table 2).

Table 2. Mean gum production (g) of *Acacia senegal* tree infested with various densities of *Anacridium m. melanorhod* for six collections in Nawa site (season 2013/2014)

Adult locust density/tree	Mean production/collection						Total
	1	2	3	4	5	6	
0	188.7 ^a	70.6 ^a	67.0 ^a	34.5 ^a	10.6 ^a	5.7 ^a	377.15
15	126.6 ^b	53.0 ^{ab}	45.3 ^{ab}	20.1 ^{ab}	6.7 ^a	5.2 ^a	253.43
30	70.5 ^c	32.0 ^b	27.6 ^b	17.7 ^{ab}	6.3 ^a	4.0 ^a	160.85
60	4.3 ^d	21.4 ^b	23.7 ^b	10.6 ^b	5.7 ^a	2.1 ^a	70.50
SE±	22.16	14.77	16.82	8.28	7.78	3.88	
CV%	27.83	40.90	50.37	47.68	130.3	111.5	

Means followed by the same letter are not significantly different at $P \leq 0.05$ using LSD; 1-6 = different collections.

Table 3 shows the effect of different densities of *Anacridium m. melanorhodon* adults on the production (ing) of *Acacia senegal* trees at Rahad site. After six collections, with the exception of the treatment 15 locust/tree, the gum production obtained with all the treatments was significantly lower compared to the control.

Table 3. Cumulative mean gum production (g) of *Acacia senegal* tree infested with various densities of *Anacridium m. melanorhodon* adults in Rahad site (season 2013/2014)

Adult locust density/tree	Mean production (g)
0	366.64 ^a
15	292.47 ^{ab}
30	225.37 ^b
60	110.39 ^c
SE±	41.17
CV%	20.27

Means followed by the same letter are not significantly different at $P \leq 0.05$ using LSD

Discussion

The relation between the Tree locust and gum production has been reviewed earlier by some authors viz: Kaatz (1963), Anti Locust Research Centre (1966), (COPR, 1982), Abdalla (1990), ElZain (1994) and Elamin *et al.* (2008). These authors indicate that there is a negative impact on gum production; nevertheless, there is some controversy about the exact magnitude of the impact of the tree locust damage on the productivity of *Gum Arabic* trees. The present study was intended to answer this question, where the results are revealed that the mean loss (%) in gum productivity caused by an artificial infestation of 60 locusts/tree was 70% and 81 % in two locations (Tables 1 and 3). These findings are in line with the results obtained by ElZain (1994), who studied the impact of the Tree locust on gum production in an area of 42 ha at Umruaba Province, North Kordofan State, Sudan, during the seasons 1991/92 and 1992/93. He estimated the loss at 86.5% from the total production.

This reduction in the productivity (g/tree) is similar to that of Wewetzer *et al.* (1993) who described the mechanism of loss as that *Acacia senegal* trees as caused by defoliation which hampers the photosynthetic capacity and hence the quantity and quality of stored carbohydrates which negatively affect the gum yield.

Conclusion

From our results, tree locust density starting from 30 locusts/tree can cause substantial reduction in gum productivity. Further studies with natural infestation levels is needed for confirmation.

Acknowledgement

The authors thank the staff of Acacia Company El Obeid, Sudan for providing the study area and encouragement. Special thanks and appreciation to the staff of CIRAD France for the limitless help, especially Antoine Foucart and Cyril Piou This paper is a contribution to the 2018 Sixth African Higher Education Week and RUFORUM Biennial Conference.

References

- Abdalla, A. A. 1990. Review of the (1989-1990) Situation of Grasshoppers, Tree Locust and African Migratory Locust in the Sudan. And outlook for (1990 -91). Ministry of Agric. PPD, Khartoum North- Sudan.
- Anonymous 1976. . Pest: *Anacridium melanorhodon* (Walker) (Including *A. m. arabafrum*, Dirsh) (Ortho., Acrididae) (Sahelian Tree Locust). Distribution maps insect pests, (ser. A), No. 355. Commonwealth Institute of Entomology
- Anti-Locust Research Centre. 1966. Anti- Locust Memoir 9, College House, Wrights Lane, London 48pp.
- Badi, K. H. M., Ahmed, A. E. and Bayoumi, M. S. 1989. The Forest of the Sudan, Khartoum. 184pp.
- Ballal, M. E. 2003. Yield trends of gum arabic from *Acacia senegal* as related to some environmental and managerial factors. Faculty of Forestry, University of Khartoum, Khartoum, Sudan. 105 pp.
- Bashir, El. M. 1997. Study on the biology, seasonal occurrence and control of the Sahelian Tree Locust *Anacridium m. melanorhodon*, (Orthoptera : Acrididae). M.Sc Thesis University of Khartoum, Sudan.
- COPR. 1982. The locust and grasshopper Agricultural manual. Centre for Overseas Pest Research, London. 690 pp.
- Dirsh, V. M. and Uvarov, B. P. 1953. Tree locusts of the genus *Anacridium* (Orth. Acrididae). (Revista Española de Entomología) XXIX (1): 7-69. Madrid. RefType: Magazine Article.
- Elamin H. M. A., Roth M. and Taha M. E. 2008. The consequences of defoliation of Gum Arabic Tree (*Acacia senegal*) by Sahelian Tree Locust (*Anacridium melanorhodon melanorhodon*) for the Gum Producers in North Kordofan State, Sudan. Proceeding of the Conference on International Research on Food Security, Natural Resource Management and Rural Development. Tropentag 2008
- Elfeel, A. A. 1996. Provenance variation in seed characteristic, germination and early growth trails of *Acacia senegal*. M. Sc. Thesis, Faculty of Forestry, University of Khartoum, Khartoum, Sudan.
- ElZain, ELB.1994. The impact of defoliation by Tree Locust *Anacridium melanorhodon melanorhodon*

- (Walker) on the gum Arabic production by hashab trees [*A. senegal* (L.) Willd]. M.Sc. Thesis, Faculty of Forestry, University of Khartoum, Khartoum, Sudan.
- Food and Agriculture Organization (FAO). 1993. Food and Agriculture Organization of the United Nations. Guide to Migrant Pest Management in Africa. FAO, Rome.
- Food and Agriculture Organization (FAO). 1999. Food and Agricultural Organization: Medicinal, Culinary and Aromatic Plants. In: The Near East. Proceedings of the International Expert Meeting organized by the Forest Products Division FAO, Forestry Department and the FAO Regional Office for the Near East 19 - 21 May 1997 Cairo, Egypt.
- Jamal, A., Berkeley, Albany, C.A. 1994. Major insect pests of gum Arabic trees *Acacia senegal* Willd. and *Acacia seyal* L. in Western Sudan. *Jor. Zeitschrift für Angewandte Entomologie* 117 (1): 10-20.
- Johnston, H. B. 1932. Notes on two locusts of minor economic importance in the Sudan. *Bulletin of Entomological Research* 23 (1): 49-64.
- Kaatz, 1963. Study on the biology, seasonal occurrence and control of the Sahelian Tree Locust *Anacridium melanorhodon melanorhodon* (Walker), (Orthoptera:Acrididae). M.Sc Thesis, University of Khartoum, Sudan.
- Mahmoud, T. E. 2004. The adequacy of price incentives on production, processing and marketing of Gum Arabic in Sudan: A case study of North and West Kordofan. PhD Thesis, Institute for International Forest and Forest Economics. Technical University, Dresden, Tharandt.
- Popov, G. and Ratcliffe, M. 1968. The Sahelian Tree Locust *Anacridium melanorhodon* (Walker); Anti-Locust Memoir 9. Ministry of Overseas Development. Anti-Locust Research Centre, College House, Wrights Lane, London, W.8 No 9:48.
- Tigani, M. H. 1965. Biology of *Polecilocerus hieroglyphicus* (Klug) and Tree Locusts of the Genus *Anacridium* in the Sudan. M.Sc. Thesis, Faculty of Science, University of Khartoum, Sudan.
- Wewetzer, A., Krall, S. and Schulz, F.A. 1993. Methods for the assessment of crop losses due to grasshoppers and locusts. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH.